

DOCUMENT RESUME

ED 182 906

EC 123 073

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TITLE Relationships Among Cognitive Measures in Learning Disabled and Non-Learning Disabled Children.
PUB DATE Sep 79
NOTE 12p.; Paper presented at the Annual Meeting of the American Psychological Association (New York, NY, September, 1979)
AVAILABLE FROM Boston University, Department of Psychology, 64 Cummington St., Boston, MA 02215
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Age Differences; *Attention; Behavior; *Cognitive Development; Cognitive Processes; Cognitive Tests; Elementary Education; Exceptional Child Research; *Hyperactivity; *Incidental Learning; *Learning Disabilities; *Memory; Sorting Procedures

ABSTRACT

The differences in performance on a variety of cognitive measures were studied in 67 learning disabled (LD) and normal elementary school children. Younger and older Ss were administered tests of conceptual sorting, central and incidental learning, and selective attention. Teacher ratings of classroom hyperactive behavior were also examined. LD Ss performed significantly worse than normal Ss on the two attention/memory tasks, but not on the conceptual sorting task. Performance on the attention/memory tasks was consistently interrelated for the normal Ss, but much less consistently for the LD Ss. Hyperactivity appeared to be related to poorer performance on the cognitive measures.
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**Relationships Among Cognitive Measures in Learning
Disabled and Non-Learning Disabled Children**

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This paper was prepared for presentation at the 1979 meeting of the American Psychological Association, New York City. The authors would like to thank Carol Piskur, Nancy Imhoff, Michele Morgan, Nancy Wilson, and the teachers and administrators of the school district for their assistance in this project. A more complete manuscript will be available from the first author at Department of Psychology, 64 Cummington St., Boston University, Boston, MA 02215.

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ABSTRACT

Differences in performance on a variety of cognitive measures and differences in patterns of ability between learning disabled (LD) and non-LD children were examined. Younger and older LD and non-LD children were administered tests of conceptual sorting, central and incidental learning, and selective attention. Teacher ratings of classroom hyperactivity-like behavior were also examined. LD children performed significantly more poorly than non-LD children on both attention/memory tasks, but not on the conceptual sorting task. Performance on the two attention/memory tasks was consistently interrelated for the non-LD children, and much less consistently so for the LD subjects. Hyperactivity appeared to be related to poorer performance on the cognitive measures. Results are discussed in terms of the learning processes and strategies needed for successful performance of these tasks.

Relationships Among Cognitive Measures in Learning Disabled and Non-Learning Disabled Children

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Despite legislators' and educators' recent attempts to specify the components of learning disability, there are still many components of the cognitive processing of learning disabled (LD) children that remain unexplored. Information about qualitative as well as quantitative differences and similarities in the thinking processes of LD and non-LD children must be the basis for the planning of diagnostic and intervention strategies. Torgesen (1975, Note 1) and Hallahan and Reeve (in press) have reviewed the task strategies used by LD children, noting that efficient strategies for problem-solving are generally not used spontaneously. Rosenthal and Allen (1978), in discussing hyperactive (who are also often LD) children, noted the relative lack of comprehensive information available about these children's attention, arousal, and cognitive abilities. The current study examines the inter-relationships of learning disability and hyperactivity with perception, concept formation, attention, and memory.

Method

Subjects

Sixty-seven children served as subjects in this study. Fifty were in regular classrooms, while seventeen were in self-contained LD classrooms. These latter subjects met the school system's definitions of "learning disabled" and scored significantly below the non-LD children on the Wide Range Achievement Test arithmetic ($t = 4.60$, $df = 18$, $p < .001$) and reading ($t = 4.29$, $df = 18$, $p < .001$) subtests.

A subsample of these children was chosen to permit analyses of developmental and diagnostic differences. The subsample consisted of 13 "younger" (M age = 109.00 months, $SD = 4.2$) and 9 "older" (M age = 138.89 months, $SD = 3.3$) non-LD children and 8 "younger" (M age = 109.25 months, $SD = 3.2$) and 8 "older" (M age = 136.25, $SD = 7.3$) LD children. Younger and older subsamples were chosen from among the total sample on the basis of their age, such that there were no significant differences between the LD and non-LD groups (younger $t = .14$, $df = 19$, n.s.; older $t = .98$, $df = 15$, n.s.).

Procedure

Each child was individually administered, in two sessions, the following tasks:

1. Vocabulary subtest of the Wechsler Intelligence Scale for Children - Revised (WISC-R) -- as a brief estimate of IQ.
2. Block Design subtest of the WISC-R -- as a measure of spatial perception and analytic thinking.

3. Conceptual Sorting task (Kagan, Moss, & Sigel, 1963) -- In this task, three line drawings of people or common objects are presented simultaneously. The child is to choose two that "go together" and to explain his/her rationale. This task has been found to be related to cognitive maturity, such that analytic strategies are used by more mature children, and functional strategies by less mature children.
4. Central-Incidental Learning (Hagen, 1967) -- In this version, seven cards, each containing a drawing of an animal and a common household object, are presented repeatedly in different orders and then are covered up. After each presentation, the child's task is to remember the placement of a particular animal (central learning). After fourteen such trials, the child is asked to match the animals and household objects that had appeared on each card (incidental learning). Thus, both memory and selective attention are measured.
5. Speeded Classification (Strutt, Anderson, & Well, 1975) -- The child is asked to sort 12 decks of 24 cards each into two piles on the basis of one attribute (e.g. form). In addition to this one relevant attribute, cards also include 2, 1, or 0 other irrelevant attributes (e.g. horizontal/vertical line; placement of a star) which the child should ignore (see Figure 1). Order of presentation of the decks was counterbalanced across subjects. Number of errors and speed in sorting indicate ability to attend selectively to the relevant attribute.
6. Teacher ratings of classroom hyperactivity (Conners, 1969).

Results and Discussion

A two-way analysis of variance was used to examine task performance differences among age and diagnostic groups. A three-way analysis of variance with repeated measures was used to examine differences among groups on different aspects of several experimental tasks. Scheffé post hoc analyses were used to examine patterns and differences in patterns among groups. Means and standard deviations for the age and diagnosis subsamples are found in Table 1. The subsamples of children were used for these analyses. Pearson product-moment correlations were also examined to discover relationships between measures for the total sample of 67 children. Because of the large correlation matrix, a more conservative alpha level of .02 was adopted.

WISC-R. LD children scored significantly lower on both the Vocabulary, $F(1, 34) = 12.46, p < .01$, and Block Design, $F(1, 34) = 4.62, p < .05$, subtests of the WISC-R. Vocabulary scores were not significantly correlated with any cognitive measures for LD, non-LD, or the total sample of children, however, analyses of covariance to separate IQ from diagnosis effects did not appear necessary, therefore. The difference between the groups on the Block Design test probably reflects the children's diagnosis as LD or non-LD.

Central-Incidental Learning. Both LD and non-LD children of both ages demonstrated primacy and recency effects on the central memory portion of this task, $F(6, 204) = 19.89, p < .001$. Pictures in the seventh (last) portion were remembered more than all those in other positions; pictures in the first position were remembered more than those in all intermediate positions ($p < .05$). Tarver, Hallahan, Kauffman, & Ball (1976) found no primacy effect on this task for their younger (M age = 8.68) LD group, although the older LD children in their study showed both primacy and recency effects. The younger children in Tarver et al's study were somewhat younger than those in the present study, possibly accounting for the difference between reports. LD children made fewer correct choices in position 3 (of 7 positions) on the central memory portion of the task, $F(1, 34) = 7.68, p < .01$; in other words, LD children had more difficulty with the intermediate items of the memory list than did non-LD children.

An index designed to reflect the relative amount of focused, or selective, attention on this task was also examined for the existence of group differences. The percentage of Central memory items answered correctly minus the percentage of Incidental items answered correctly ($\%C - \%I$) was significantly higher for non-LD than LD children, $F(91, 34) = 4.06, p < .05$. The non-LD children, that is, were able to attend selectively to the relevant portion of the task more effectively than the LD children.

No main effects or interactions for age for any of the measures on this task were found, nor were performance measures correlated with age (with the exception of a correlation between age and position 3 performance in the central memory portion, $r = .38, df = 48, p < .01$, for the non-LD children only).

Speeded Classification. LD children made more errors in sorting cards into piles than did non-LD children, $F(1, 34) = 5.28, p < .03$. Younger children also tended to make more errors than the older ones, $F(1, 34) = 3.69, p < .06$. A significant age X diagnosis interaction, $F(1, 34) = 5.89, p < .02$, revealed that these effects were largely accounted for by the younger LD children making significantly more errors than any other group ($p < .05$). The mean amounts of time taken to sort each deck of cards were examined to discover whether groups differed depending on how many (0, 1, or 2) irrelevant features were on the card and on whether the relevant feature was form (circle vs. square), line (horizontal vs. vertical), or star (above vs. below the figure). Performance on the first half of the decks the child sorted was also compared to performance on the second half to assess any practice effects. Overall, younger children, $F(1, 34) = 11.30, p < .01$, and LD children, $F(1, 34) = 5.39, p < .025$, took longer to sort the decks. In examination of a significant age X diagnosis interaction, $F(1, 34) = 4.89, p < .03$, it seemed that younger LD children took a significantly longer time in sorting than the older LD and non-LD groups ($p < .01$) and the younger non-LD group ($p < .05$). When cards included two irrelevant features, sorting time was significantly slower ($p < .05$) than when they included no irrelevant features, $F(2, 68) = 7.86, p < .001$. LD children seemed particularly affected by the irrelevant features, as revealed in a significant diagnosis X features interaction, $F(2, 68) = 4.01, p < .02$. LD children sorting decks with two irrelevant dimensions performed more slowly than when they sorted zero-irrelevant-features decks and more slowly than the non-LD children under all conditions ($p < .05$). There was also a significant

age X diagnosis X features interaction, $F(2, 68) = 3.96, p < .02$. The younger LD children sorted more slowly than the other groups; when sorting two-irrelevant-features decks, they were slower than all other groups except young LD children in the one-irrelevant feature group ($p < .05$). When sorting these one-irrelevant-feature decks, younger LD children were slower than the older children in all conditions and slower than younger non-LD children sorting zero- and two-irrelevant-features decks ($p < .05$). Finally, when sorting zero-irrelevant-features decks, younger LD subjects were slower than older LD ones in the same condition ($p < .05$). In short, the younger LD children appeared to be the least able group to attend selectively to the relevant features of the cards during sorting.

The type of relevant feature on which the sorting was based was found to be highly related to sorting time, $F(2, 68) = 45.37, p < .001$. Star placement was the most time-consuming ($p < .05$), followed by direction of the line which, in turn, took significantly more time than the form discrimination ($p < .05$). There were not significant interactions between age or diagnosis with this factor, however. For subjects as a whole, there appeared to be a practice effect for sorting, such that the first six decks were sorted more slowly than the last six, $F(1, 34) = 10.22, p < .01$, even though the order of the particular decks was counterbalanced across subjects. An age X order interaction was also found; younger children sorted significantly more slowly on the first half of the task than on the second half ($p < .05$) and more slowly than the older children on both halves ($p < .01$).

An interesting difference in patterns of intercorrelations between Central-Incidental Learning and Speeded Classification scores was found between the total samples of non-LD and LD children. For the non-LD children, the two tasks did, as would be expected, intercorrelate. For example, the mean sorting time of the non-LD subjects on the Speeded Classification task was significantly related to their Central-Incidental Learning task number of choices needed to finally choose correctly ($r = .42, df = 48, p < .01$), to correct central memory choices in the primacy positions 1 ($r = -.45, df = 48, p < .01$) and 2 ($r = -.40, df = 48, p < .01$), and to their selective attention index ($\bar{X}C - \bar{X}I$), ($r = -.37, df = 48, p < .01$). In contrast, for the LD children, the only significant correlation between scores on these two tasks was that found between the number of choices needed to finally choose correctly the animal pictures' correct positions on the Central-Incidental Learning task and the degree of their failure on the two-irrelevant-features decks of the Speeded Classification task ($r = .75, df = 15, p < .001$). The latter datum was defined as the number of times the child had to re-sort the deck to reach the passing criterion of fewer than four errors. Finally, for LD but not non-LD children, Block Design scores tended to be correlated with sorting time ($r = -.54, df = 15, p < .05$).

Conners Hyperactivity Ratings. When all of the LD and non-LD children were examined together, thus providing a wider range of scores, the Conners teacher ratings of the child's classroom behavior (in which a higher score denotes more hyperactivity-like behavior) were positively related to their Central-Incidental Learning performance on position 7 (the recency position) of the central memory portion of the task ($r = .31, df = 65, p < .01$). On the Speeded Classification task, more hyperactive-like children tended to take

a longer time in sorting ($r = .38$, $df = 65$, $p < .01$), especially in sorting the two-irrelevant-features decks ($r = .43$, $df = 65$, $p < .001$), to make more errors ($r = .32$, $df = 65$, $p < .01$), and to have to re-sort the decks more often to reach criterion ($r = .30$, $df = 65$, $p < .02$). In this study, the LD children had significantly higher Conners scores than the non-LD children, $F(1, 34) = 34.67$, $p < .001$; the interpretation of diagnostic and behavioral contributions is therefore somewhat confounded. Conners scores were not, on the other hand, related either to Vocabulary ($r = -.08$, $df = 65$, n.s.) or to Block Design ($r = -.08$, $df = 65$, n.s.) scores, so that behavior problems and learning ability seem to be rather independent in this sample.

Conceptual Sorting. Contrary to previous findings with younger children (Kagan et al, 1963; Copeland & Weissbrod, Note 2), no diagnostic or age differences were found on this task. Post hoc analysis of a main strategy effect, $F(2, 68) = 13.30$, $p < .001$, revealed that the superordinate strategy was used less than the functional or analytic strategies across groups ($p < .05$).

Conclusions

LD children generally had more difficulty with the two attention tasks than non-LD children. The difficulties seemed to be more pronounced and profound on the Speeded Classification task (the one with no memory component) than the Central-Incidental Learning task. Diagnostic groups did not differ in their overall central or incidental learning scores, although LD children did demonstrate less selective attention. Hallahan and his colleagues have reported similar findings (Tarver, et al, 1976; Tarver, Hallahan, Cohen, & Kauffman, 1977), attributing the LD children's difficulties to a developmental lag in their use of effective labeling and verbal rehearsal. How much these strategies would affect performance on the Speeded Classification task, however, is unclear. Ability to label the relevant features of the cards would probably be a helpful skill; verbal rehearsal is probably less relevant.

The two attention tasks differ in other ways than the inclusion of a memory component; the explanation of diagnosis differences may need, therefore, to be broader in order to explain the LD children's poorer performance on the Speeded Classification task. Perhaps LD children are particularly sensitive to being timed. Problems in spatial perception characteristic of LD children might also have negatively influenced their performance on the task requiring quick form and placement discriminations. This argument is supported by the negative relationship noted between Block Design scores and sorting time. On the other hand, that no diagnosis main effects or interactions were found for the feature factor weakens this argument. The LD children in this study did perform more poorly than non-LD children on the Speeded Classification task, suggesting that they performed more like younger children. This task requires very little abstraction, memory, or higher-level cognitive functioning; it is basically a matching task. That LD children still performed poorly suggests that the explanations offered above should be examined closely. The relative lack of intercorrelation between the two attention measures for the LD children and the quite consistent intercorrelation for the non-LD children suggests that the learning processes needed for success have developed at different rates in the LD child.

Specific analysis of any behavioral component of the LD label was addressed by examining the relationship between Conners hyperactivity ratings and task performance. More hyperactive-like children performed less well on both attention tasks, although Conners scores were not specifically related to the selective attention index. The relevance of attention to hyperactivity has gained recent recognition (Rosenthal & Allen, 1978; Safer & Allen, 1976) and is supported by these findings.

Performance Score Means and
Standard Deviations

		Younger		Older	
		Non-LD	LD	Non-LD	LD
Central-Incidental Memory					
Central	M	6.62	5.50	6.67	7.13
	SD	2.02	0.93	1.73	2.70
Incidental	M	3.92	5.13	3.11	3.88
	SD	1.71	2.42	2.09	1.89
XC - XI + 1.00	M	0.91	0.66	1.03	0.85
	SD	0.30	0.33	0.32	0.35
Trials Needed	M	19.15	21.88	19.33	18.88
	SD	7.60	5.46	6.25	8.34
Speeded Classification					
Errors	M	3.92	28.50	6.56	5.88
	SD	6.89	32.00	7.33	5.79
Time/Deck	M	22.48	32.33	19.98	20.22
	SD	4.96	11.89	4.15	2.50
Re-Sorts Needed	M	0.08	1.38	0.22	0.38
	SD	0.28	2.13	0.44	0.52
Conceptual Sorting					
Functional	M	5.46	6.00	6.11	5.50
	SD	2.85	3.07	3.59	2.00
Analytic	M	7.92	6.75	6.89	7.63
	SD	3.93	3.24	3.98	2.83
Superordinate	M	2.62	3.25	2.89	2.75
	SD	2.66	2.31	1.90	2.82

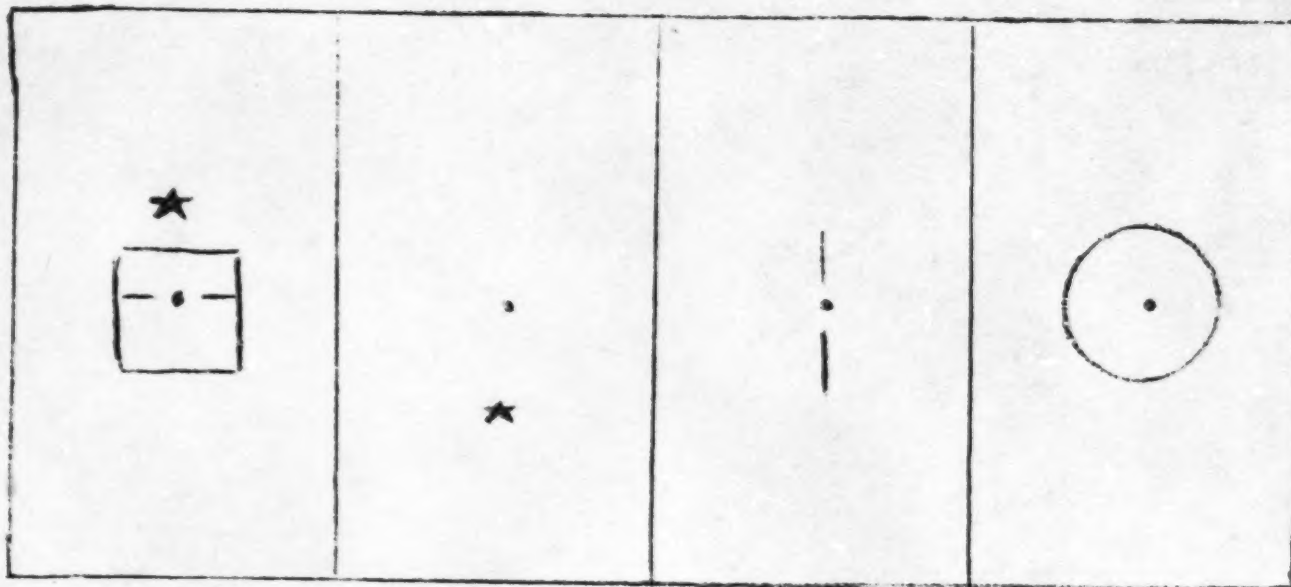
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Figure 1
Examples of Speeded Classification Cards



1 relevant
2 relevant

star relevant
no irrelevant

line relevant
no irrelevant

form relevant
no irrelevant